FY 2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: Feb 2004
Exhibit R-2

BA: 01 PROGRAM ELEMENT: 0601153N
PROGRAM ELEMENT TITLE: Defense Research Sciences

COST: (Dollars in Thousands)

Project Number & Title	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Defense Research Sciences	393,056	375,363	375,812	390,131	397,748	405,168	413,046

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This program sustains U.S. Naval Science and Technology (S&T) superiority, provides new technological concepts for the maintenance of Naval power and national security, and helps avoid scientific surprise. Additionally, it exploits scientific breakthroughs and provides options for new Future Naval Capabilities (FNCs). It responds to S&T direction from Department of the Navy (DON) Naval Power 21 (NP21) Transformational Roadmap, and Chief of Naval Operations (CNO) N70 Mission Capability Package (MCP) requirements for long term Navy and Marine Corps improvements. Defense Research Sciences is in consonance with future warfighting concepts and doctrine developed at the Naval Warfare Development Command and the Marine Corps Combat Development Command, and enables technologies to significantly improve the Joint Chiefs of Staff (JCS) Future Joint Warfighting Capabilities. It is managed by the Office of Naval Research (ONR) through Program Officers at ONR Headquarters, and the base program of the corporate Naval Research Laboratory (NRL).

The vision of the DON S&T strategy is "to inspire and guide innovation that will provide technology-based options for future Navy and Marine Corps Capabilities", where "Innovation is a process that couples Discovery and Invention with Exploitation and Delivery". DON Basic Research is the core of Discovery and Invention. It includes scientific study and experimentation directed toward increasing knowledge and understanding in national-security related aspects of physical, engineering, environmental and life sciences. Basic research efforts are developed, managed, and related to more advanced aspects of research in some hundred-plus technology and capability-related 'thrusts', which are consolidated in 15 Research Areas. These in turn support the major motivational research focus areas of the Navy and Marine Corps after Next: maritime and space environments that impact operational capability, information science/knowledge management in network-centric operations, sensors and electronic systems for surveillance and tactical applications, energy/power/propulsion for performance gain and sustainment, advanced air/surface/undersea and multi-environment Naval platforms design/signature reduction, weapons systems for Naval forces, and superior human performance/training/care of Sailors and Marines.

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Key aspects of the program are the four ONR Grand Challenges which 'inspire and guide' the direction of research: Naval Battlespace Awareness, Electric Power Sources for the Navy and Marine Corps, Naval Materials by Design, and Multifunctional Electronics for Intelligent Naval Sensors; and the National Naval Responsibilities (NNRs), fields upon which a wide range of fundamental naval capabilities depend, and in which ONR is and likely will remain the principal US research sponsor. NNRs are ratified only after close scrutiny, and currently comprise Ocean Acoustics (started FY99), Underwater Weaponry (started FY02), and Naval Engineering (started in FY03).

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

PROGRAM CHANGE SUMMARY:

	FY 2003	FY 2004	FY 2005
FY 2004-2005 President's Budget Submission	396,330	368,517	377,223
Cong. Rescissions/Adjustments/Undist.Reductions	-7,053	-4,254	0
Congressional Actions	0	11,100	0
Execution Adjustments	3,779	0	0
Inflation Savings	0	0	-932
Rate Adjustments	0	0	-479
FY 2005 President's Budget Submission	393,056	375,363	375,812

PROGRAM CHANGE SUMMARY EXPLANATION:
Technical: Not applicable
Schedule: Not applicable

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B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 2003	FY 2004	FY 2005
Ocean/Space Sciences	140,615	141,150	142,119

Efforts include: Battlespace environments; environmental processes; environmental model development; environmental sensors and data; data assimilation and information exploitation; validation studies; space platforms; environmental biology/quality; cooperative ASW; wide area ASW surveillance; and battlegroup ASW defense.

FY 2003 Accomplishments:

- Initiated investigation of fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
- Initiated an integrative ecosystem study to develop environmental predictors of whale presence or absence to reduce impacts of Naval systems to marine mammals.
- Commenced development of major ionospheric interactions research capability at the High Frequency Active Auroral Research Program (HAARP) to identify or improve Command, Control, Communications, Intelligence (C3I) capabilities for Naval undersea warfare applications.
- Continued validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.
- Developed techniques for utilizing high resolution, motion imagery to predict beach evolution.
- Developed global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/electro-optical/Infrared(EO/IR) sensors, and the performance of Naval weapons in the atmosphere and under the sea.
- Developed improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.

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• Developed new techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
• Developed new methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.
• Developed understanding of physical and biological processes responsible for the formation, maintenance, and breakdown of thin oceanographic layers which have a significant impact on undersea warfare sensors and weapons.

FY 2004 Plans:
• Initiate field programs to understand physical and biological processes responsible for the formation, maintenance, and breakdown of thin oceanographic layers which have a significant impact on undersea warfare sensors and weapons.
• Continue enhancement of ionospheric interactive research capabilities at HAARP and begin program of S&T development leading to improved performance of Naval undersea applications.
• Develop programs to validate techniques for utilizing high resolution, motion imagery methods to predict beach evolution.
• Conduct opportunistic validation of global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/electro-optical(EO)/infrared (IR) sensors, and the performance of Naval weapons in the atmosphere and under the sea.
• Implement investigation of fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
• Assess improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.
• Develop and initiate validation of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
• Assess validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.
• Implement field trials of an integrative ecosystem study to provide environmental predictors of whale presence or absence to reduce impacts of Naval systems to marine mammals.
• Develop advanced methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.

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FY 2005 Plans:

• Initiate an assessment of the role of emerging sub-mesoscale parameterization techniques for improving next generation high resolution/high accuracy environmental models.
• Initiate design evaluation for a persistent mobile sampling network based on autonomous undersea vehicle platform and sensor technologies.
• Continue and assess field trials of an integrative ecosystem study to provide environmental predictors of whale presence or absence to reduce impacts of Naval systems to marine mammals.
• Analyze field programs to validate techniques for utilizing high resolution, motion imagery methods to predict beach evolution.
• Assess validation of global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/EO/IR sensors, and the performance of Naval weapons in the atmosphere and under the sea.
• Assess the fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
• Develop advanced improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.
• Pursue additional validation of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
• Assess validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.
• Implement field programs to understand physical and biological processes responsible for the formation, maintenance, and breakdown of thin oceanographic layers which have a significant impact on undersea warfare sensors and weapons.
• Implement advanced methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.
• Complete all enhancements to HAARP interactive research, providing full capability to address all anticipated applications for Naval undersea warfare operations.

	FY 2003	FY 2004	FY 2005
Electronics/Sensor Sciences	42,510	43,430	49,222

Efforts include: Sensing, diagnostics, and detectors; navigation and timekeeping; nano-electronics; wide band gap power devices; real-time targeting; EO/IR electronics; EO/IR electronic warfare; EO/IR sensors for surface/aerospace surveillance; Radio Frequency (RF) sensors for surface/aerospace surveillance; solid state electronics; vacuum electronics; advanced multi-function RF system (AMRFS); and RF electronic warfare.

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FY 2003 Accomplishments:

- Began effort to complete the HAARP Gakona Facility by completing the antenna array pad and foundations. Five research campaigns were conducted.
- Developed an approach to extract multiple unresolved target detections from a single range bin. Technique allows improvements in initiating and maintaining tracks on multiple targets in a single range bin of a radar.
- Applied field plate technology to GaN HEMTs (High Electron Mobility Transistors) with a resulting increase in power density to 30 Watts/mm and efficiencies of over 70%.
- Proved the theory of temporal-spatial circuit architecture for direct RF sampling, and demonstrated devices for a sub-100 micron sensor.
- Demonstrated production of a Bose-Einstein condensate of molecules.
- Achieved quantum cascade laser (QCL) emission at 6 microns producing 640 mW of continuous-wave power at room temperature, compared with previous record of 20 mW.
- Developed optical track of moving target algorithms and are integrating them into Unmanned Air Vehicles (UAVs) for convoy surveillance.
- Developed and demonstrated thin film diffractive lenses on a passive millimeter wave sensor.
- Proved and used the distributed polarization concept to demonstrate effective three-dimensional carrier gas channels for future power nitride semiconductor HEMTs.
- Developed several techniques to deposit high quality Magnesium Diboride (MgB2) superconducting films as first step in 3 terahertz (THz) digital device process.
- Commercialized nanoimprint lithography and adopted it in the International Technology Roadmap for Semiconductors (ITRS) 2003.
- Developed a miniature inexpensive highly sensitive fluxgate magnetometer.
- Completed research for low frequency RF markers and tags.

FY 2004 Plans:

- Incorporate non-equilibrium considerations into modeling of realistic superconducting tunnel junctions when barrier is near the metal/insulator transition.
- Demonstration of the crossover between the Bardeen-Cooper-Schrieffer and Bose-Einstein condensation phase transitions.
- Explore optical super resolution techniques with atmospheric turbulence reduction techniques.
- Research multiple target extraction techniques from single and adjacent range cells to handle unresolved targets. Integrate the extractor in the existing MD Benchmark for system performance evaluations.
- Assess impact of field plate technology on scaling of power density of HEMT output periphery, broad band matching and reliability.

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- Employ distributed polarization effect to enable linear higher power microwave bipolar transistors.
- Demonstrate temporal-spatial sampling circuits and architectures for digital-to-analog conversion.
- Demonstrate sub 100 micron cell sized sensor circuitry.
- Reduce emission wavelength of room temperature quantum cascade laser to 4.5-4.8 microns and further increase power to meet laser source requirements for infrared countermeasures against heat-seeking missiles.
- Continue advanced height finding and detection algorithms for high frequency radar.
- Continue project to complete HAARP facility. All antennas will be installed by end of 2004. Planned research campaigns during ongoing construction will investigate Extremely Low Frequency (ELF) modulation and efficiency improvements and magnetospheric propagation.
- Design and test coupled miniature fluxgate magnetometers to improve sensitivity.
- Demonstrate Vertical Magnetic Random Access memory (VMRAM).

FY 2005 Plans:
- Initiate non-cooperative target identification from multiple aspects.
- Investigate superresolution signal processing techniques for closely spaced and unresolved targets in Doppler, range and direction of arrival spaces for a variety of radars.
- Investigate ultra high speed logic and multiple-quantum-well devices with a goal of >500 GHz samplers, in support of analog-to-digital conversion.
- Demonstrate basis for improved time and frequency standards using quantum-entangled ions and atoms.
- Research superlattice detectors for future infrared detectors.
- Demonstrate Cellular Nonlinear Network (CNN) fast image processor with integrated multi-spectral focal plane array sensors.
- Improvement in the performance of the HAARP Facility will begin with the installation of transmitters.
- Continue research program with more advanced capability to generate and evaluate ELF techniques.
- Explore function of sensitive miniature fluxgate magnetometers.
- Demonstrate bipolar microwave circuit demonstration employing distributed polarization (graded composition) base growth and processing technology.
- Complete proof that superconductive A to D converters have uniquely positive performance critical to their use in wideband receivers.

	FY 2003	FY 2004	FY 2005
Advanced Naval Materials Sciences	72,456	66,940	65,832

Efforts include: Structural materials; functional materials; synthesis, processes, and characterization; prediction and simulation; and maintenance reduction technology.

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FY 2003 Accomplishments:

- Initiated work to develop the scientific basis for revolutionary approaches to discover advanced dielectrics for energy storage for eventual application in electric war ships.
- Developed understanding and procedures for growing controlled iron films with adlayer cappings of arsenic and gallium for spin injection structures and devices.
- Developed novel magnetic materials for ship board high power applications.
- Developed physics-based models to predict weld induced distortion in high strength, low alloy steels.
- Continued work to improve heat treatments and low alloy compositions for high strength low alloy steels with superior strength and toughness for enhanced shipboard blast protection, reduced weight, and reduced production cost.
- Explored three dimensional nature of solid phases in ferrous alloys for improved high strength steels.
- Designed, synthesized and developed advanced polymers including high temperature and flame resistant polymer composites and ceramics for aerospace and ship applications.
- Performed three dimensional microstructure analysis of high and low carbon steels to provide the scientific basis for fatigue and failure processes.
- Established the scientific basis for advanced materials with improved potential for blast resistance.
- Developed x-ray computed microtomography of composite materials using a synchrotron light source.
- Explored materials and structures capable of limiting optical transmission at variable wavelengths for enhanced eye and sensor protection against agile laser illumination.
- Explored dynamic behavior of high strength steels as a function of microstructure.
- Developed atomic-scale simulations of friction and wear in metallic sliding systems.
- Explored the use of a contact potential difference probe (Kelvin effect) as a sensor to determine the in situ spectrum in sliding metallic contact.

FY 2004 Plans:

- Begin to explore the processing and microstructures of novel titanium alloys that may be enabled by new co-reduction of mixed metallic oxide processes.
- Develop first principle methods to calculate second and third rank tensor properties of sonar materials such as lead zirconate titanate and lead magnesium niobate.
- Advance the understanding of deformation mechanisms in nanometer scale aluminum and steels to provide new high strength-high toughness alloys for naval platforms.
- Develop understanding and methodology to predict high deformation rate blast processes for engineered topological structures.

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- Identify stress corrosion control methods for friction stir welded high-strength aluminum alloys using advanced thermal treatments, chemical modifications, and surface mechanical processes to tailor compressive stresses.
- Link ab initio calculations of structure to mesoscale simulations of alloy behavior to provide the scientific basis for the design of advanced steels for naval ship applications.
- Develop and validate physics-based models of thermal and materials flow during friction stir welding of steels, including the development of residual stresses that will lead to distortion.
- Identify, quantify, and control the atomic scale properties that limit or enhance the performance of magnetic semiconductor materials.
- Develop integrated bio-magneto-electronic structures and devices for experimental evaluation.
- Develop the science of sliding contact and lubrication using physical and chemical first principles.
- Develop first-principles based methodologies for predicting the thermodynamics and kinetics controlling microstructural evolution for the design of advanced naval steels.
- Design, synthesize and develop welding consumables and process methodologies for joining superaustenitic stainless steels.
- Develop theoretical basis for composite materials behavior based on x-ray computed micro-tomography.
- Continue to develop understanding and constitutive models of dynamic behavior of naval steels.

FY 2005 Plans:
- Explore superplasticity in advanced high strain nanometer scale ceramic composites to provide the basis for the development of such materials in naval applications.
- Develop materials and fabrication science for fugitive phase processes for engineered topological structures for ship blast protection.
- Identify hydrogen embrittlement resistant high strength alloys based on nickel-cobalt-chrome-molybdenum material systems.
- Begin first lubrication-by-design experiments.
- Begin to explore the design of advanced steels for weldability based on previous first-principles efforts.
- Explore solid-state joining and localized microstructural modification of weldments in titanium alloys for improved toughness and fatigue resistance.
- Explore advanced coatings with multifunctional corrosion/fouling properties.
- Explore advanced theoretical concepts for corrosion control.
- Extend first principle calculations of sonar materials tensor piezoelectric and dielectric properties to complex solid solutions to provide the basic understanding and predictive capability for ultra high strain materials.

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• Continue to link ab initio calculations of structure to mesoscale simulations of alloy behavior for the design of advanced steels.
• Continue the theoretical development of composite materials behavior based on x-ray computed micro-tomography.
• Continue to explore advanced integrated bio-magneto-electronic materials, structures and devices.
• Continue development of first-principles based methodologies for predicting and controlling microstructural evolution for the design of naval steels.
• Continue exploration of processing and microstructure development of novel titanium alloys.
• Continue development of physics-based models of thermal and materials flow during friction stir welding, including the development of residual stresses that will lead to distortion.
• Continue to develop understanding and constitutive models of dynamic behavior of naval steels.
• Continue to explore and develop materials for high energy density passive power electronics.

	FY 2003	FY 2004	FY 2005
Naval Platform Design Sciences	17,776	17,023	20,677

Efforts include: Surface/subsurface reduced signatures; free-surface, subsurface and propulsor hydromechanics; hull life assurance; advanced ship concepts; distributed intelligence for automated survivability; advanced electrical power systems; air vehicles; air platforms propulsion and power; air platforms survivability and signature control; special aviation projects; UAV/UCAV; environmental quality; and logistics.

FY 2003 Accomplishments:
• Developed reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
• Developed an integrated acoustics model for complex propulsors.
• Developed infrared ship predictions for low observable ships that include bi-directional reflectance distribution functions.
• Conducted quantitative measurements of bubble concentrations at-sea around a ship to develop prediction methods.
• Examined simulations of far wakes in a stratified medium evolution of vertical vortices.
• Measured and analyzed high levels of turbulence interacting with blade flow for noise generation.
• Developed a method to infer, for the first time, fluctuating pressure in turbulent flow from Three Dimensional (3-D) Particle Image Velocimetry (PIV) measurements.

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• Validated Six Degrees-Of-Freedom (6DOF) Reynolds Average Navier-Stokes (RANS) predictions of surface ship forced roll response.
• Developed a Large-Eddy Simulation (LES) prediction method for unsteady propulsor flow.
• Developed physics-based analysis tools and models for non-linear circuits and loads and highly coupled ship board power systems.
• Developed robust turbulence models in three dimension boundary layers to improve submarine maneuvering predictions.
• Developed next-generation infrared scene model to enable optimal infrared reflectance ship surfaces.
• Improved and extended durability of foul-control marine coatings to reduce energy use and adverse environmental impacts, and to extend the time between physical removal of hull and marine structure foulants.
• Investigated the fate and effects of chemical and biological contaminants in marine/estuarine environments.
• Continued work on understanding, predicting, and controlling scattering from discontinuities such as antennas and ship-sea surface radar cross section interactions.
• Incorporated nonlinear incident wave representations in a ship motions prediction method.
• Conducted micro-bubble drag reduction experiments on a large plate.
• Constructed and tested a new instrument for spatial measurement of surface waves around models.
• Developed a hydrodynamic test facility on a small boat platform to enable in situ performance of foul-release coatings.

FY 2004 Plans:
• Initiate efforts to design and test stability and control mechanisms for power distribution in nonlinear circuits.
• Initiate scientific approaches to alternate heat transfer and cooling methodologies.
• Initiate assessment of the fate and effects of chemical and biological contaminants in marine/estuarine environments.
• Conduct studies of thermoelectric material requirements for shipboard cooling applications.
• Evaluate electromagnetic signature basic physics including scattering from multi-scaled dielectric materials and evaluation of visual rendering studies into high fidelity infrared modeling.
• Identify and rank bubble sources around surface ships.
• Evaluate a breaking wave prediction method.
• Quantify a 3-D turbomachinery flow using stereo PIV.
• Conduct first measurements of effects of full scale level turbulence on appendage fluctuating surface pressures.
• Conduct detailed measurements of total wave field and resulting ship motions using new instrumentation.

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• Further develop computational mechanics to provide predictive capabilities of acoustics, linear and nonlinear dynamic response and failure mechanisms of structures.
• Develop reliability methodology for hull structures and hybrid joints.
• Develop physics based understanding of composite materials to characterize thermo-mechanical behavior, response to multi-axial loads and improve mechanical properties.
• Develop methods to reduce acoustic modeling requirements and techniques for physical modeling at small scale to better characterize signature phenomenology and control and structure amplified flow noise.
• Develop expanded scaleable simulation capabilities for virtual distributed control.
• Explore and evaluate control system algorithms and strategies in a virtual environment including affordability issues.
• Establish limits for energy-time transients as a function of power system impedance parameters.
• Determine durability of foul-control marine coatings to reduce energy use and adverse environmental impacts and to extend the time between physical removal of hull and marine structure foulants.
• Continue efforts to understand and control the generation and propagation of far-field jet noise.
• Continue examination of scientific methods for pollution prevention, waste reduction and hazardous material reduction for Naval Operations.
• Continue development of reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
• Continue development of LES method for unsteady propulsor flow predictions.
• Develop high thermal conductivity polymer nanocomposites.
• Construct and test run a thermoacoustic piezoelectric generator.
• Complete work on quantification of active combustion control.

FY 2005 Plans:
• Initiate development of advanced magnetocaloric materials for magnetic refrigeration.
• Initiate effort on pierside robotic hull fouling control / surveillance technologies.
• Evaluate electromagnetic signature basic physics to further understand low observable and infrared technology performance against evolving threats.
• Quantify and model bubble sources around surface ships for prediction methods.
• Validate a breaking wave prediction method against experimental data.
• Examine turbomachinery flow using holographic PIV.
• Validate 6DOF RANS predictions of surface ship motion.
• Validate LES predictions of turbomachinery flow against experimental data.
• Further examine computational mechanics in order to address prediction of acoustic signatures in complex structures, modeling of structural failures and optimization, sensitivity analysis and error control.

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- Integrate distributed heterogeneous control simulation capability into the overall control system simulation infrastructure.
- Test and evaluate control system algorithms and strategies in a virtual environment including affordability issues.
- Further evaluate stability and control of model electrical power systems.
- Assess durability of foul-control marine coatings to reduce energy use and adverse environmental impacts and to extend the time between physical removal of hull and marine structure foulants.
- Initiate the Research Tools Development Consortia Program under the Program Decision Memorandum (PDM) for University Research - Engineering Design Consortia.
- Continue development of reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
- Continue scientific approaches to alternate heat transfer and cooling methodologies.
- Continue assessment of the fate and effects of chemical and biological contaminants in marine/estuarine environments.
- Continue efforts to understand and control the generation and propagation of far-field jet noise.
- Continue examination of scientific methods for pollution prevention, waste reduction and hazardous material reduction for Naval Operations.
- Continue development of computational mechanics to provide predictive capabilities of acoustics, linear and nonlinear dynamic response and failure mechanisms of structures.
- Continue to develop methods to reduce acoustic modeling requirements and techniques for physical modeling at small scale to better characterize signature phenomenology and control and structure amplified flow noise.
- Continue development of reliability methodology for hull structures and hybrid joints.
- Continue development of physics based understanding of composite materials to characterize thermo-mechanical behavior, response to multi-axial loads and improve mechanical properties.
- Determine most promising foul-release approaches based on silicones to meet Navy durability requirements for further development and testing.
- Perform 1/2 and full-scale engine testing of most promising on-board noise reduction technologies (e.g.air/water injection).

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	FY 2003	FY 2004	FY 2005
Information Sciences	55,003	47,926	46,322

Efforts include: Computational theory and tools for design, communication, and control of intelligent autonomous systems; decision theory, algorithms, and tools; heterogeneous information integration, management, and presentation; information assurance, secure and reliable information infrastructure for Command and Control; mathematical optimization for optimal resource allocation and usage; modeling and computation of complex physical phenomena; modeling and computation for electromagnetic and acoustic wave propagation and scattering; seamless, robust connectivity and networking; and expeditionary operations Command, Control, Communications, Computers Intelligence Surveillance and Reconnaissance(C4ISR).

FY 2003 Accomplishments:
• Initiated development of mathematical optimization framework and heuristic algorithms to be used as basis for network design, optimal sensor allocation, and logistics.
• Initiated development of mathematical theory and computational algorithms that take advantage of multi-pathing effects for improved sensing.
• Continued refinement of techniques for ensuring privacy of information transferred across public networks.
• Continued development of turbo-codes and iterative processing techniques to enable high data rates for wireless communication applications.
• Continued to refine techniques for extracting maximum knowledge from multi-modal imagery, text, and electromagnetic and acoustic signal data.
• Continued to investigate methods to deal with light dispersion on image formation underwater to enable precise navigation, station keeping, and mapping capabilities for unmanned underwater vehicles.
• Continued development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
• Developed theory and algorithms for autonomous systems to recognize a particular scene from different perspectives.
• Solved one of the most-famous and long-standing conjectures in discrete mathematics, known as the Strong Perfect Graph Conjecture, whereby providing a mathematical basis for development of new techniques for design of more efficient communications networks.
• Developed basis for collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
• Developed adaptive routing protocols to select the links for routing information packets that maximize communication network throughput with minimum energy consumption.

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FY 2004 Plans:

- Initiate efforts on modeling chaotic phenomena in network operations.
- Initiate efforts for integrating domain knowledge into learning methods.
- Initiate efforts for semantic-based information gathering.
- Initiate efforts in extended augmented/virtual reality with haptics, sound, and olfactory components.
- Continue development of mathematical optimization framework and heuristic algorithms that serve as theoretical and computational basis for network design, optimal sensor allocation, and logistics.
- Continue refinement of techniques for ensuring privacy of information transferred across public networks.
- Continue development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
- Continue to refine techniques for extracting maximum knowledge from multi-modal imagery, text, and electromagnetic signal data.
- Continue to investigate methods to deal with light dispersion on image formation underwater to enable precise navigation, station keeping, and mapping capabilities for unmanned underwater vehicles.
- Continue efforts for enabling teams of autonomous systems to work together and work on representations for evolution of cooperative behaviors, including efforts in multi-modal interactions with autonomous systems.
- Continue developing framework for dealing with effect of variable latencies in communication within teams of humans and autonomous systems.
- Continue efforts on development of mathematical foundations for image enhancement, feature extraction, feature-based/texture-based compression, denoising, and segmentation; data representation and metrics, content-based indexing and retrieval; reconstruction, interpolation, and registration; and scene analysis and image understanding.
- Continue efforts on quantum computing and cryptography.
- Continue efforts on general automated theorem prover technologies and biometric technologies for authentication.
- Continue efforts in multi-modal dialog.
- Continue efforts in physics-based modeling of natural phenomena.
- Continue efforts in mathematical techniques for inverse problems, including reliable approximate solutions in 3D; adequate representation of the physics of the media and the scatterer; and improved resolution of structural and material properties.
- Refine theory and algorithms for autonomous systems to recognize a particular scene from different perspectives.
- Refine turbo-codes and iterative processing techniques to enable high data rates for wireless communication applications.

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• Develop a framework for collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
• Develop adaptive routing protocols to select the links for routing information packets that maximize communication network throughput with minimum energy consumption.

FY 2005 Plans:
• Develop computational framework for integrating information of disparate sources - Program Decision Memorandum (PDM) for University Research - Surveillance & Knowledge Systems.
• Develop a systematic approach that will serve as a theoretical and computation basis for automated image understanding and automatic object recognition.
• Continue development of mathematical optimization framework and heuristic algorithms that serve as theoretical and computational basis for network design, optimal sensor allocation, and logistics.
• Continue to refine techniques for extracting maximal knowledge from multi-modal imagery, text, and electromagnetic signal data.
• Continue efforts for enabling teams of autonomous systems to work together, on representations for evolution of cooperative behaviors and in multi-modal interactions with autonomous systems.
• Continue developing framework for dealing with effect of variable latencies in communication within teams of humans and autonomous systems.
• Continue efforts on development of mathematical foundations for image enhancement, feature extraction, feature-based/texture-based compression, denoising, and segmentation; data representation and metrics, content-based indexing and retrieval; reconstruction, interpolation, and registration; and scene analysis and image understanding.
• Continue efforts on quantum computing and cryptography and on biometric technologies for authentication.
• Continue efforts on general automated theorem proven technologies.
• Continue efforts on modeling chaotic phenomena in network operations.
• Continue efforts for multi-modal dialog.
• Continue efforts for integrating domain knowledge into learning methods.
• Continue efforts for semantic-based information gathering.
• Continue efforts for in physics-based modeling of natural phenomena.
• Continue efforts in extended augmented/virtual reality with haptics, sound, and olfactory components.
• Continue efforts in automatic inference of context from images/video.
• Continue efforts in mathematical techniques for inverse problems, including reliable approximate solutions in 3D; adequate representation of the physics of the media and the scatterer; and improved resolution of structural and material properties.

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• Complete refinement of techniques for ensuring privacy of information transferred across public networks.
• Complete collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
• Complete development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
• Complete methods to deal with light dispersion on image formation underwater to enable precise navigation, station keeping, and mapping capabilities for unmanned underwater vehicles.

	FY 2003	FY 2004	FY 2005
Human Performance and Medical Sciences	22,019	23,240	25,198

Efforts include: human factors and organizational design; manpower, personnel, and training; integrated avionics, displays, and advanced cockpit; pattern recognition; biosensors, biomaterials, bioprocesses; marine mammals; casualty care and management; fit and healthy force; casualty prevention; biorobotics; expeditionary operations training and education; and chemical-biological defense.

FY 2003 Accomplishments:
• Initiated the development of new theoretical treatment of the differences in individual humans.
• Initiated studies on microbial degradation of energetic compounds in marine sediments.
• Initiated research effort on the physiological effects of exposure to non-lethal stimuli for a better understanding of human vulnerabilities and enhanced protection.
• Continued research on human cognition and performance to create more realistic simulations and to improve decision algorithms.
• Continued research into the efficacy of a group of compounds that mimic or assist endogenous defenses to hearing damage to sailors and marines.
• Continued work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
• Continued work on genomics, genetic immunization, stem cells, and signal transduction.
• Completed specification of computational linguistic techniques to emulate one-to-one tutoring behavior.
• Completed proofs-of-concept of microbial synthesis of energetics, micro-biofuel cell, and modular, reagentless, and fast biosensors.
• Completed robust algorithms for threat and situation assessment decision aids, automatic target recognition in cluttered environments, and detection and classification of buried mines.

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FY 2004 Plans:
• Initiate program to combine cognitive architectures with computational neuroscience to better predict human performance.
• Initiate efforts to develop next-generation, supramolecular antibiotics.
• Initiate work to recharge UUV sensor packages with sediment fuel cell.
• Initiate development of novel multidisciplinary approaches to human-activity inference from video imagery to enable force protection and counterterrorism.
• Continue development of novel genetic sequencing tools for marine algae and seaweeds.
• Continue work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
• Continue work on genomics, genetic immunization, stem cells, and signal transduction.
• Continue non-lethal bioeffects research.

FY 2005 Plans:
• Initiate study of methods to allow active vision for mobile robotics.
• Initiate study of social networks for counterterrorism.
• Continue development of novel multidisciplinary approaches to human-activity inference from video imagery to enable force protection and counterterrorism.
• Continue program to combine cognitive architectures with computational neuroscience to better predict human performance.
• Continue efforts to develop next-generation, supramolecular antibiotics.
• Continue work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
• Continue work on genomics, genetic immunization, stem cells, and signal transduction.
• Continue non-lethal bioeffects research.
• Continue work to recharge UUV sensor packages with sediment fuel cell.

	FY 2003	FY 2004	FY 2005
Weapon and Energy Sciences	30,258	24,677	26,442

Efforts include: Undersea Weaponry including undersea energetics, undersea guidance and control, and supercavitation physics; expeditionary operations firepower and maneuver; ground mine countermeasures; energetic materials; advanced energetics; propulsion; electrochemical power sources; and novel power sources and energy transfer.

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FY 2003 Accomplishments:

- Identified new approaches to efficiently transfer thermal, electrical and optical energy from primary sources.
- Initiated research in materials and processes for novel concepts in efficient energy conversion.
- Conducted preliminary studies on multivalent ion insertion in nanoscale vanadium pentoxide cathode materials to improve the capacity of rechargeable lithium batteries.
- Analyzed synchronization of 19 diode lasers to produce intense beams.
- Designed a thermoacoustic piezoelectric generator working via a temperature gradient.
- Expanded fundamental understanding of direct electrochemical oxidation in solid oxide fuel cells and the use of logistic fuels.
- Developed improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays, magnetometers for target classification and signal processing algorithms for counter-countermeasure.
- Expanded the University Laboratory Initiative program to provide a further infusion of educated and career minded scientists and engineers in support of the NNR for undersea weapons research.
- Synthesized and characterized new energetic materials with higher energy density and acceptable sensitivity.
- Continued conducting basic research related to critical S&T (including vehicle control, maneuverability, and stability) associated with the development of high-speed supercavitating vehicles (HSSV).
- Demonstrated active and passive combustion control of supersonic and subsonic flows to reduce combustion instability and pressure oscillations and to improve performance, while reducing emissions.
- Performed research to develop pulse detonation engine (PDE) technology for operation on logistics fuels.
- Expanded research into new materials and processes for converting thermal to electric energy.
- Continued work on developing the scientific basis of nanostructure enhancement of direct energy conversion materials performance for power generation.
- Continued development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
- Continued improvements to catalyzed carbon microfiber electrode development for semi-fuel cells.
- Continued to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Continued to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continued to develop spectroscopic capabilities to accurately determine aluminum combustion characteristics in various oxidizing environments.

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• Continued to develop synthesis routes to difluoramino-based and organometallic-based highly energetic ingredients.
• Developed materials for enabling rechargeable batteries with an energy density approaching 500 watt-hours per kilogram.
• Created metamodel-Kriging models for performance measurement of potential HSSV designs.
• Demonstrated cyclic pulse detonation engine (PDE) operation with JP-10 fuel.
• Performed numerical simulations of multi-tube multi-cycle PDE operation with nozzles.
• Identified record high figure of merit bulk thermoelectric material for power generation.
• Completed Visual/Optical approach to determine supercavitating projectile dynamics with its cavity.
• Demonstrated that seismic Rayleigh waves can be used to generate detectable resonances in anti-personnel landmines buried in a wide range of soil types.
• Developed 6DOF simulation environment of HSSV motion and trajectories.

FY 2004 Plans:
• Begin to explore the union of explosion/detonation theory with electron transfer theory.
• Design and explore new processes for ceramic, organic and hybrid dielectric materials for energy storage for electric warship needs.
• Develop interaction between the basic research in the direct oxidation and reforming of logistics fuels and the related tri-service programs to improve transition pathways for relevant breakthroughs.
• Investigate novel initiation techniques, optimize injection parameters, and demonstrate integrated single tube operation for Pulse Detonation Engine (PDE).
• Enhance activities in nano-science based approaches to novel power sources.
• Enhance research on energy transfer science and research into materials and processes for energy efficiency.eeee
• Synchronize coupled diode laser arrays.
• Continue investigations toward modeling and exploiting the nonlinear seismic interactions between buried land mines and their surrounding soil for purposes of landmine detection.
• Continue development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
• Continue research in man-portable electrical energy storage and conversion.
• Continue conducting basic research related to critical Science and Technology (including vehicle control, maneuverability, and stability) associated with the development of HSSVs.
• Continue developing improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays and signal processing algorithms for counter-countermeasure.

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- Continue the University Laboratory Initiative program.
- Continue research into alternative binder materials for explosives and propellants which are compatible with higher energy ingredients.
- Continue to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Continue to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continue to develop spectroscopic capabilities to accurately determine aluminum combustion characteristics in various oxidizing environments.
- Continue to develop synthesis routes to difluoramino-based and organometallic-based highly energetic ingredients.
- Continue computer code refinements and investigation of supercavitating vehicle dynamics and instability.
- Continue work in science related to direct energy conversion.
- Continue work in science related to new materials and processes (including nanostructures) for converting thermal to electric energy for shipboard power generation and waste energy conversion.
- Construct and test run a thermoacoustic piezoelectric generator.
- Complete work on quantification of active combustion control.

FY 2005 Plans:
- Initiate research using Program Decision Memorandum (PDM) II funding into fundamental understanding of initiation/energy release processes of reactive and other energetic materials as part of the Advanced Energetics program.
- Implement new & nanostructured materials design concepts for direct energy conversion and waste energy conversion.
- Investigate multi-tube multi-nozzle Pulse Detonation Engines (PDEs) and multi-tube common nozzle PDEs.
- Identify, synthesize and evaluate novel metal and non-metal based ingredients for reactive and other energetic material applications and characterize their energy release contributions.
- Continue exploring novel materials and approaches toward high energy storage dielectrics.
- Continue investigations toward modeling and exploiting the nonlinear seismic interactions between buried land mines and their surrounding soil for purposes of landmine detection.
- Continue development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
- Continue research in man-portable electrical energy storage and conversion.

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- Continue developing improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays and signal processing algorithms for counter-countermeasure.
- Continue the University Laboratory Initiative program.
- Continue to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Continue to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continue to develop spectroscopic capabilities to accurately determine aluminum combustion characteristics in various oxidizing environments.
- Continue to develop synthesis routes to organometallic-based highly energetic ingredients.
- Continue research into alternative binder materials for explosives and propellants which are compatible with higher energy ingredients.
- Continue conducting basic research related to critical Science and Technology (including vehicle control, maneuverability, and stability) associated with the development of HSSVs.
- Continue efforts in novel power source development.

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CONGRESSIONAL PLUS-UPS:

	FY 2003	FY 2004
ACADEMY FOR CLOSING AND AVOIDING ACHIEVEMENT GAPS	0	989

Basic research to examine methods of determining college student's strengths and weaknesses in sciences and tailor a program to improve in these gaps.

FY 2004 Plans
• Initiate a program for: (1) systemic mentoring, including research participation, of 50-100 undergraduate college Science, Technology, Engineering and Mathematics students known as scholars, (2) extensive educational enrichment services for 150-200 K-12th grade students during summer, and (3) the conduct of research, publishing, and delivering presentations and workshops for the community at large.

	FY 2003	FY 2004
CENTER FOR PHOTOCHEMICAL SCIENCES	0	495

Basic research associated with development and use of a photopolymerization process for rapid curing of novel anti-corrosive bilge coatings, nonskid deck coatings, and/or low solvent hull AF coatings.

FY 2004 Plans
• Initiate support of the Center for Photochemical Sciences.

	FY 2003	FY 2004
CONSORTIUM FOR MILITARY PERSONNEL RESEARCH	1,332	0

Manpower is the critical resource to the Naval service. Retention, accession, selection, classification, distribution, assignment, personnel policy and training management are all vital to successfully manning it.

FY 2003 Accomplishments
• Completed efforts in military personnel research that advanced the Navy’s ongoing efforts in the areas of retention, accession, selection, classification, distribution, assignment, personnel policy and training management.

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	FY 2003	FY 2004
INTEGRATED WMD DETECTION AND COLLECTION SYSTEM	0	2,076

Basic research in the area of micro sensors for unmanned air vehicle (UAV) reconnaissance systems.

FY 2004 Plans
• Initiate development of sensors tailored to collect evidence of weapons of mass destruction sized to fit on small UAVs.

	FY 2003	FY 2004
NANOSCALE ARCHITECTURES FROM PROTEIN NANOCAGES	0	1,978

Basic research in three areas: 1) biomedical nanoparticles for drug delivery and imaging; 2) magnetic nanoparticles; and 3) catalytic nanoparticles.

FY 2004 Plans
• Establish a center for bioinspired nanomaterials.

	FY 2003	FY 2004
NAVAL BASIC RESEARCH	4,986	0

The solar radiation spectrum affects militarily critical areas such as communications, navigation, surveillance and guidance systems. Expanded knowledge and understanding of this spectrum will dramatically improve the fidelity of models of the Earth’s upper atmosphere, thus greatly enhancing our ability to mitigate the effects of radiation-induced space weather. Detection of toxic substances is also of critical importance because of the military’s need to operate in potentially harmful chemical and biological dangerous environments during wartime.

FY 2003 Accomplishments
• Investigated the solar spectrum and its effects on military systems.
• Conducted modeling of cell-based biosensor arrays in an effort to assist in the rapid detection and identification of potentially toxic substances.

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	FY 2003	FY 2004
NEUTRON DETECTOR	0	989

Neutron detectors are used to monitor nuclear weapons, detect fissionable materials, and assess radiation exposure of personnel in real time. Existing devices are very large, expensive, easily damaged, inefficient, and require large amounts of power. Novel neutron detection devices based on boron carbide semiconductors are small, lightweight, able to withstand high temperatures and corrosion, and can be powered by small batteries or solar cells. Thus they can be used in handheld systems, or in applications where such monitoring must be stealthy.

FY 2004 Plans
• Research and testing to improve detector efficiencies and increase the range of the neutrons detected, and to improve reliability.

	FY 2003	FY 2004
QUANTUM OPTICS RESEARCH	4,672	2,472

Basic research into quantum optics shows promise in the development of novel device configurations for infra-red sources and detectors that have high applicability to Naval sensors and weapons.

FY 2003 Accomplishments
• Initiated work in infrared semiconductor lasers based on coherent wave mixing, infrared imaging up-conversion and resonant four-wave mixing, ultra-sensitive spectroscopy, spontaneous emission manipulation, quantum computation and information processing, and quantum thermodynamics.
• Continued designing experimental versions of these devices built based on theoretical advances in areas having to do with quantum interference processes such as lasing without inversion.

FY 2004 Plans.
• Continue work in infrared semiconductor lasers.

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	FY 2003	FY 2004
ROBOTIC COUNTERMINE TECHNOLOGIES	1,429	1,978

Mine countermeasures in shallow water and particularly, the surf zones are extremely challenging. Use of robots designed with aquatic characteristics and features have been shown to be particularly promising in this task based on earlier ONR and DARPA research.

FY 2003 Accomplishments
• Designed an undersea robotic platform based on biologically derived engineering concepts.

FY 2004 Plans
• Enhance efficient operation, power supply, and autonomous control procedures.

C. OTHER PROGRAM FUNDING SUMMARY:

NAVY RELATED RDT&E:
PE 0601152N In-House Laboratory Independent Research

NON-NAVY RELATED RDT&E:
PE 0601102A Defense Research Sciences (Army)
PE 0601102F Defense Research Sciences (Air Force)

D. ACQUISITION STRATEGY:
Not Applicable.